

AMENDMENTS TO THE CLAIMS

This complete listing of claims will replace all prior versions, and listings, of claims in the application:

1. (Currently Amended) A rate controller for a block-based video encoder, comprising:
a variable bit rate (VBR) video controller generating a first quantization step size for a current picture;
a constant bit rate (CBR) video controller operating in tandem and independently from the VBR controller and generating a second quantization step size for the current picture; and
a selector configured to ~~switch back and forth between~~ receive independent calculations of said first quantization step size and said second quantization step size for the current picture from the VBR video controller and the CBR video controller and select a maximum permissible quantization step size from said first quantization step size and said second quantization step size for use by a quantizer in quantizing transform data associated with the current picture.
2. (Original) The rate controller of claim 1, further comprising:
an input for processing at least one parameter of operation for at least one of said VBR controller and said CBR controller.
3. (Original) The rate controller of claim 2, wherein said at least one parameter includes at least one of a target peak bit rate, a target average bit rate, a maximum quantization scale, a minimum quantization scale, a target quantizer scale, a target buffer scale, a VBV buffer size, and a time constant for said VBR rate controller to track changes in long-term average bit rate.
4. (Previously Presented) The rate controller of claim 1, wherein an average bit rate of said VBR controller tracks variations in long-term average bit rate of an output bit stream of said block-based video encoder.
5. (Original) The rate controller of claim 4, wherein said VBR controller comprises a proportional integral controller adapted for tracking variations in long-term average bit rate.

6. (Original) The rate controller of claim 5, wherein said VBR controller includes a programmable time constant for adapting to changes in long-term average bit rate.

7. (Currently Amended) The rate controller of claim 4 5, wherein said CBR controller comprises:

- a picture analysis module configured to classify macroblocks of a current picture into at least two different macroblock types and calculate a statistical indicator of complexity for each macroblock type;

- a complexity model module coupled to said picture analysis module configured to form a predicted picture complexity estimate based on a statistical frequency of said macroblock types within said current picture;

- a bit allocation module adapted to form a bit allocation consistent with said predicted picture complexity estimate; and

- a picture-level quantizer assignment module adapted to assign a quantization step size consistent with said bit allocation.

8. (Original) The controller of claim 7, wherein said indicator of complexity comprises an energy value calculated from an activity measurement of macroblocks.

9. (Original) The controller of claim 7, wherein said bit allocation module comprises:

- an ideal bit allocation module configured to calculate an ideal bit allocation based on an estimated complexity of a picture;

- a video bitstream verification (VBV) fullness adjustment module configured to adjust said ideal bit allocation to maintain a desired VBV buffer fullness range; and

- a VBV compliance adjustment module configured to adjust said ideal bit allocation to maintain VBV compliance.

10. (Currently Amended) A constant bit rate controller for a video compression encoder, comprising:

- a picture analysis module configured to classify macroblocks within a current picture by type, each macroblock type having distinct rate-quantization properties, determine a statistical

frequency of each of at least two different types of macroblocks within the current picture and an activity-based energy value for each macroblock type indicative of a number of bits required to encode each macroblock type, and ~~for forming~~ generate at least one statistical indicator of the complexity of each of said at least two different types of macroblocks based on quantization-dependent bits in the each of said at least two different types of macroblocks;

a complexity model module coupled to said picture analysis module configured to form a predicted picture complexity estimate based on statistics of said macroblocks;

a bit allocation module adapted to form a bit allocation consistent with said predicted picture complexity estimate; and

a picture-level quantizer assignment adapted to assign a quantization step size to said quantization-dependent bits consistent with said bit allocation.

11. (Original) The constant bit rate controller of claim 10, wherein said bit allocation module comprises:

an ideal bit allocation module configured to calculate an ideal bit allocation based on an estimated complexity of a picture;

a video bitstream verification (VBV) fullness adjustment module configured to adjust said ideal bit allocation to maintain a desired VBV buffer fullness range;

a VBV compliance adjustment module configured to adjust said ideal bit allocation to maintain VBV compliance.

12. (Cancelled)

13. (Currently Amended) The constant bit rate controller of claim 12, wherein ~~each~~ said energy value is determined by a calculation including: a difference measurement of each macroblock type between original pixel luminance values and mean pixel luminance values.

14. (Original) The constant bit rate controller of claim 10, wherein said at least one statistical indicator of said picture analysis module comprises a time averaged energy estimate for at least one macroblock type.

15. (Original) The constant bit rate controller of claim 10, wherein said complexity model module generates a measurement of the complexity of each type of macroblock and a running estimate of macroblock type complexities.

16. (Currently Amended) A method of constant bit rate (CBR) rate control in a video compression encoder, comprising:

for a current picture, classifying macroblocks by type and determining a statistical frequency of the macroblock types, each macroblock type having distinct rate-quantization properties;

generating a statistical indicator indicative of a complexity of each type of macroblock based on quantization-dependent bits in each type of macroblock;

determining an activity-based energy value for each macroblock type indicative of a number of bits required to encode each macroblock type;

predicting picture complexity to form a predicted picture complexity by forming a weighted sum of macroblock types, wherein each macroblock type has a weight that increases with its statistical frequency and with a value of said statistical indicator;

generating a bit allocation consistent with said predicted picture complexity; and

assigning a quantizer step size consistent with said bit allocation.

17. (Currently Amended) The method of claim 16, wherein said ~~generating a statistical indicator~~ determining an activity-based energy value for each macroblock type comprises:

calculating a difference measurement of each macroblock type between original pixel luminance values and mean pixel luminance values.

18. (Currently Amended) The method of claim 17, ~~further comprising:~~

~~for each macroblock type, forming an~~ wherein the activity-based energy value is formed by scaling a corresponding difference measurement value by an empirical factor and averaging scaled difference measurement values over all macroblocks of the same type in said current picture.

19. (Previously Presented) The method of claim 18, further comprising: utilizing a macroblock aging parameter to generate a time averaged energy estimate for at least one macroblock type.

20. (Original) The method of claim 19, further comprising: generating a measurement of the complexity of each type of macroblock.

21. (Original) The method of claim 18, further comprising: generating a running estimate of macroblock type complexities.

22. (Original) The method of claim 21 wherein said generating a running estimate of macroblock type complexities comprises: combining macroblock complexities for a current picture with values of a previous picture.

23. (Original) The method of claim 18, wherein said values of said previous picture are weighted by an aging factor.

24. (Original) The method of claim 16, further comprising: generating an intra energy output for bit prediction in a video bitstream compliance check.

25. (Original) The method of claim 24, further comprising: measuring the intra energy for a current picture and combining it with a measure of the intra-energy for a previous picture.

26. (Original) The method of claim 25, wherein said measure of the intra-energy for said previous picture is weighted by a picture level aging parameter.

27. (Currently Amended) A method of variable bit rate control in a video compression encoder having a variable bit rate controller with a peak bit rate and a selectable average bit rate, comprising:

measuring changes in ~~long-term~~ the average bit rate of an output bitstream of said encoder over time for a current picture; and

~~adjusting said average bit rate of said variable bit rate controller to track said changes in long term average bit rate~~ a target bit allocation for said current picture by second-order feedback control based on a difference between said average bit rate and an actual bit rate said changes and according to a time constant set to be larger than a scene.

28. (Previously Presented) The method of claim 27, wherein said time constant is set to be larger than the longest scene of any given complexity in the bitstream.

29. (Currently Amended) The method of claim 27, wherein said adjusting comprises:
adapting to said changes in ~~long term~~ average bit rate according to a proportional integral controller response.

30. (Currently Amended) A method of rate control in a video compression encoder, comprising:

generating a first quantization step size using a constant bit rate video encoder for a current picture;

forming a second quantization step size using a variable bit rate video encoder operating in tandem and independently from the constant bit rate encoder for the current picture; and

~~switching back and forth between~~ receiving independent calculations of said first quantization step size and said second quantization step size for the current picture from the constant bit rate encoder and the variable bit rate encoder to select a maximum quantization step size from said first quantization step size and said second quantization step size for use in quantizing compressed video image data associated with the current picture.

31. (Original) The method of claim 30, wherein said forming comprises:
tracking long-term average bit rates.

32. (Original) The method of claim 30, wherein said forming comprises:
tracking long-term average bit rates using a proportional integral encoder.